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SYSTEMATIC REVIEW and META-ANALYSIS article

The impact of continuous glucose monitoring on glycemic control, health outcomes, and safety during Ramadan fasting: A systematic review and meta-analysis

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Abstract: Ramadan fasting imposes unique metabolic demands on individuals with diabetes mellitus (DM), creating increased risks of hypoglycemia and hyperglycemia. Continuous Glucose Monitoring (CGM) technology offers real-time glucose data that may mitigate these risks; however, no systematic quantitative synthesis has previously evaluated CGM's role specifically during Ramadan fasting. This study aims to systematically evaluate the impact of CGM on glycemic control outcomes - including Time in Range (TIR), Time Above Range (TAR), Time Below Range (TBR), Mean Amplitude of Glycemic Excursions (MAGE), and HbA1c - and safety outcomes among adults and adolescents with DM during Ramadan fasting. A systematic review and meta-analysis was conducted in accordance with PRISMA 2020 guidelines. PubMed, Scopus, and the Cochrane Library were searched from January 2014 through December 2024. Risk of bias was assessed using ROBINS-I for non-randomized studies and RoB2 for randomized controlled trials. Random-effects meta-analyses were performed using Comprehensive Meta-Analysis (CMA) version 3, with heterogeneity quantified using the I^2 statistic. Seven studies encompassing 485 participants (DM I: 4 studies; DM II: 3 studies) across six countries were included. CGM use was associated with improved TIR in most studies, with one study achieving significance [15]. Pooled meta-analytic results for TBR showed a non-significant reduction during Ramadan (standardized mean difference: - 0.138; 95% CI: - 0.650 to 0.375; p = 0.599). Substantial heterogeneity was observed across outcomes (I^2 range: moderate to high). HbA1c data showed inconsistencies across studies, partly attributable to unit-reporting discrepancies identified during data extraction. Safety outcomes trended toward improvement with CGM use. CGM appears to enhance glycemic control and patient safety during Ramadan fasting, particularly by improving TIR and supporting timely detection of hypoglycemic events, given the small number of included studies and substantial heterogeneity.

Introduction

Ramadan, the holy month of fasting observed by 1.8 billion Muslims globally, presents unique and clinically significant metabolic challenges for individuals living with diabetes mellitus. During this period, complete abstinence from food and fluids from dawn to sunset - which may extend up to 20 hours per day, particularly in

summer months at higher latitudes - profoundly disrupts normal glucose homeostasis. Despite religious exemptions available to those with serious medical conditions, approximately 148 - 150 million Muslims with diabetes mellitus (DM) choose to fast during Ramadan [1, 2], underscoring the critical need for evidence-based guidance.

The physiological consequences of prolonged Ramadan fasting create a therapeutic paradox: Patients face simultaneous risks of severe hypoglycemia during extended fasting hours and postprandial hyperglycemia following the Iftar meal. This disordered glycemic pattern can precipitate serious complications including diabetic ketoacidosis, severe dehydration, and prothrombotic states [3]. Epidemiological data document a 4.7-fold increase in severe hypoglycemia episodes among patients with DM I and a 7.5-fold increase in those with DM II during Ramadan compared to non-fasting periods [4]. These risks are compounded in the Middle East and North Africa region, which carries the world's highest diabetes prevalence at 17.6%, projected to reach 163 million affected individuals by 2050 [5].

Continuous Glucose Monitoring (CGM) technology - encompassing real-time CGM (rtCGM) and intermittently scanned CGM (isCGM/flash CGM) - represents a transformative advance in diabetes management. By providing continuous interstitial glucose readings, trend arrows, and customizable alert thresholds, CGM enables patients and clinicians to respond proactively to impending hypoglycemia or hyperglycemia [6]. Multiple randomized controlled trials and observational studies in non-fasting contexts have demonstrated CGM's efficacy in reducing HbA1c, improving TIR, and decreasing glycemic variability [7]. However, the evidence base for CGM use specifically during the Ramadan fasting context remains fragmented, consisting of small, methodologically heterogeneous studies across diverse populations. Critically, no systematic review has previously performed a quantitative synthesis of CGM's impact on glycemic outcomes during Ramadan. This represents a significant gap in the evidence needed to inform clinical guidelines, particularly those issued by the International Diabetes Federation-Diabetes and Ramadan (IDF-DAR) International Alliance and the American Diabetes Association. The present systematic review and meta-analysis was conducted to address this gap by synthesizing available evidence on the impact of CGM on glycemic control parameters - specifically TIR, TAR, TBR, MAGE, and HbA1c - as well as safety outcomes in patients with DM I and DM II observing Ramadan fasting.

Materials and methods

Study registration and reporting: This systematic review and meta-analysis was conducted and reported in accordance with the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) statement [8]. The review protocol was registered prospectively in PROSPERO (CRD420250632481.

Inclusion criteria: Studies were eligible if they: Enrolled adults or adolescents (aged ≥ 12 years) with DM I or DM II; Involved participants observing Ramadan fasting; Incorporated CGM as an intervention or monitoring tool; Reported at least one quantitative glycemic outcome (HbA1c, TIR, TAR, TBR, MAGE, or mean glucose); Were published in English between January 2014 and December 2024; and Were randomized controlled trials (RCTs) or non-randomized observational studies (prospective cohort, longitudinal, or observational designs).

Exclusion criteria: Studies were excluded if they: Did not specifically focus on CGM technology; Enrolled non-diabetic populations exclusively; Did not report quantifiable glycemic or safety outcomes; Were case reports, editorials, conference abstracts without full-text data, or expert opinion pieces; or used CGM solely for blinded retrospective profiling without clinical decision support.

Information sources and search strategy: A comprehensive literature search was conducted in PubMed/ MEDLINE, Scopus, and the Cochrane Central Register of Controlled Trials (CENTRAL). The final search was

conducted in December 2024. Search terms combined controlled vocabulary (MeSH) and free-text terms including: CGM, flash glucose monitoring, FreeStyle Libre, DM, Ramadan, Islamic fasting, glycemic control, time in range, hypoglycemia, and hyperglycemia. Boolean operators (AND/OR) were applied, and filters were set for English-language publications and the specified date range. Grey literature was explored through ClinicalTrials.gov and relevant conference proceedings; however, peer-reviewed publications were ultimately included. The full PRISMA flow diagram is presented in **Figure 1**.

Figure 1: PRISMA 2020 flow diagram

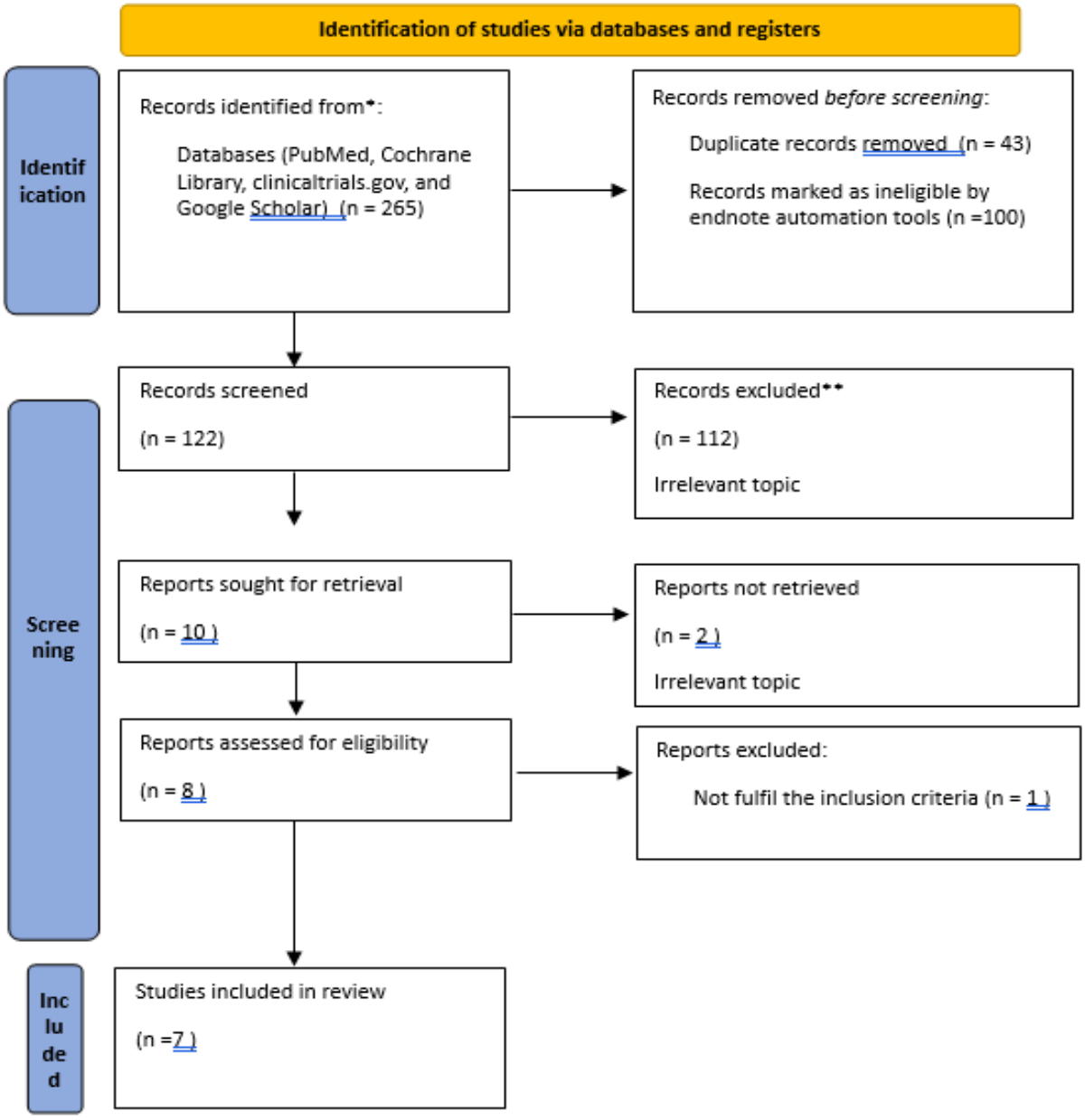

Identification of studies via databases and registers
Identif ication
Records identified from*:
Databases (PubMed, Cochrane Library, clinicaltrials.gov, and Google Scholar) (n = 265)
Records removed before screening:
Duplicate records removed (n = 43)
Records marked as ineligible by endnote automation tools (n =100)
Scree ning
Records screened
(n = 122)
Records excluded**
(n = 112)
Irrelevant topic
Reports sought for retrieval
(n = 10)
Reports not retrieved
(n = 2)
Irrelevant topic
Reports assessed for eligibility
(n = 8)
Reports excluded:
Not fulfil the inclusion criteria (n = 1)
Inc lu de d
Studies included in review
(n =7)

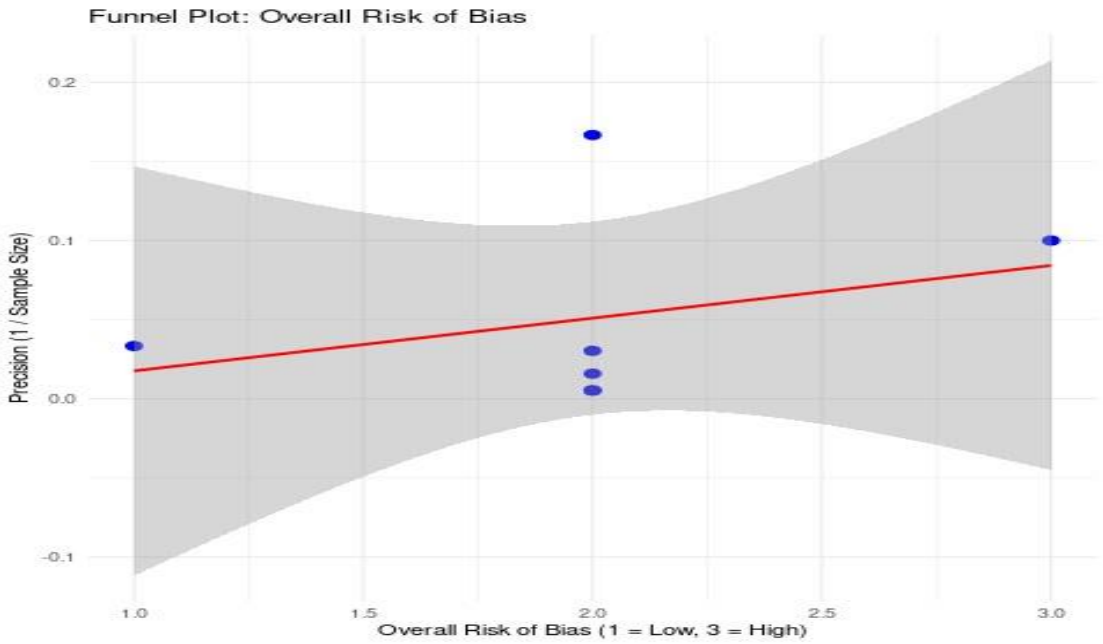
Figure 1

Study selection and data extraction: Two independent reviewers (blinded to author and journal) screened all retrieved records at the title/abstract level and subsequently at the full-text level. Discrepancies were resolved through discussion or adjudication by a third reviewer. Data were extracted using a standardized, pre-piloted extraction form capturing: study design, country, participant characteristics (age, gender, diabetes type, duration,

treatment regimen), CGM system used, duration of Ramadan fasting period studied, and all reported glycemic and safety outcomes across pre-Ramadan, during-Ramadan, and post-Ramadan phases. Where data were ambiguous or missing, study authors were contacted where possible. An important data quality issue identified during extraction concerned HbA1c reporting: some studies appeared to report HbA1c in mmol/mol (IFCC units) while others used percent (NGSP/DCCT units), without explicit labeling. This unit inconsistency significantly affects the interpretability of pooled HbA1c analyses and is addressed explicitly in the Limitations section. Values from a previous study, where reported pre-Ramadan HbA1c of 92 ± 45.2 is implausible in percent units but plausible in mmol/mol (≈ 10.6%), were handled conservatively and excluded from pooled HbA1c synthesis [11].

Risk of bias assessment: Risk of bias in non-randomized studies was assessed using the Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I) tool [9], which evaluates seven domains: Confounding, selection, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes, and selection of reported results. For the single RCT [15], the Cochrane Risk of Bias tool version 2 (RoB2) was applied. Assessments were conducted independently by two reviewers, with disagreements resolved by consensus (**Figure 2**).

Figure 2: Funnel plot of publication bias assessment



Statistical analysis: Where two or more studies reported the same outcome using comparable metrics, data were pooled using a random-effects model (DerSimonian-Laird method) to account for expected between-study heterogeneity arising from differences in CGM technology, diabetes type, treatment regimen, and population characteristics. Effect measures included standardized mean differences for continuous outcomes reported with different scales, and mean differences for outcomes reported in identical units. Statistical heterogeneity was assessed using the I^2 statistic, with values of ≥ 50.0% considered to represent substantial heterogeneity. All meta-analyses were performed using Comprehensive Meta-Analysis software, version 3. Funnel plots were constructed where ≥ 10 studies per outcome were available to assess publication bias; given the limited number of included studies, formal Egger's regression was not performed. For outcomes where meta-analysis was not feasible due to insufficient studies or incompatible data, narrative synthesis was conducted following Synthesis Without Meta-analysis guidance.

Results

Study selection: The database search yielded 312 records after de-duplication. Following title and abstract screening, 28 full-text articles were assessed for eligibility. Seven studies met all inclusion criteria and were included in the final synthesis (**Figure 1**). The primary reasons for exclusion of full-text articles were: absence of CGM as the primary monitoring modality (n = 11), no Ramadan-specific data reported separately (n = 6), non-diabetic populations (n = 2), and conference abstracts without full data (n = 2).

Study characteristics: The seven included studies enrolled a total of 485 participants across six countries (UAE, Indonesia, Bahrain, Saudi Arabia, and a multinational study), published between 2015 and 2024 (**Table 1**). Study designs included five prospective observational/longitudinal studies, one randomized pilot study [15], and one observational study using automated insulin delivery systems. Three studies focused exclusively on Type 2 DM [10, 11, 13], three on DM I [14-16], and one included both types [12]. CGM systems varied considerably: Medtronic iPro1 and iPro2 (professional/blinded CGM), FreeStyle Libre (isCGM/flash), Dexcom G6 (rtCGM), and automated insulin delivery systems with integrated CGM. Sample sizes ranged from 6 [14] to 195 [12] participants.

Table 1: Descriptive characteristics of included studies

Ref.	Nation	DM	CGM System	Study design	Treatment	N	M/F	Age	DM Duration
10	UAE	T2	Medtronic Gold	Prospective cohort	Metformin, Gliptin, SU, Insulin	63	39/24	44.9 ± 12.1	Not reported
11	UAE	T2	Medtronic iPro2	Prospective observational	Non-insulin oral agents	33	9/24	55.0 ± 10.4	9.8 ± 6.8
12	UAE	T1	Flash CGM (FreeStyle Libre)	Prospective observational	Insulin ± oral agents	195	77/92	47.7 ± 16.5	Not reported
13	Indonesia	T2	Medtronic iPro1	Prospective longitudinal	Oral antidiabetic agents	10	4/6	52.5 ± 6.3	7.7 ± 7.2
14	Multi-national	T1	Automated insulin delivery system	Observational	Automated insulin delivery	6	5/1	33.7 ± 4.8	23.5 ± 7.9
15	Bahrain	T1	Dexcom G6 (rtCGM)	Randomized pilot study	Insulin pump (CSII)	30	14/16	22.4 ± 3.9	7.5 ± 4.7
16	Saudi Arabia	T1	Not specified	Prospective observational	MDI and insulin pump	148	108/78	17.0 ± 5.0	9.0 ± 4.0

Note: *Al Hayek, Al Dawish [16] CGM system was not specified in the source publication. T1 = Type 1 DM; T2 = Type 2 DM; MDI = multiple daily injections; CSII = continuous subcutaneous insulin infusion; OAD = oral antidiabetic drug. Color coding in Table 2: Green = Low risk; Yellow = Moderate risk; Red = High risk*

Risk of bias assessment: Risk of bias results are summarized in **Table 2**. The majority of included studies demonstrated moderate overall risk of bias. Harbuwono et al. [13] was rated high overall risk, primarily due to selection bias (convenience sample, n=10) and incomplete outcome reporting. AlGhatam et al. [15] demonstrated the lowest risk of bias, reflecting its randomized design. Common sources of bias across studies included inadequate control for confounding variables (dietary composition, physical activity, concurrent medications),

variability in CGM device capabilities and wear durations, and inconsistent definitions of hypoglycemia and hyperglycemia thresholds. The high missing data domain rating in a study of Hassanein et al. [12] reflects incomplete post-Ramadan follow-up data.

Table 2: Risk of bias assessment (ROBINS-I and RoB2)

Ref.	Confounding	Selection bias	Classification	Deviation	Missing Data	Measurement	Reporting	Overall ROB
10	Moderate	Moderate	Low	Low	Moderate	Low	Low	Moderate
11	High	Low	Low	Moderate	Low	Moderate	Low	Moderate
12	Low	Moderate	Low	Low	High	Low	Low	Moderate
13	Moderate	High	Low	Low	Moderate	Low	Moderate	High
14	Low	Moderate	Moderate	Moderate	Low	High	Low	Moderate
15	Moderate	Low	Low	Low	Low	Low	Moderate	Low
16	Low	Moderate	Low	High	Moderate	Low	Low	Moderate

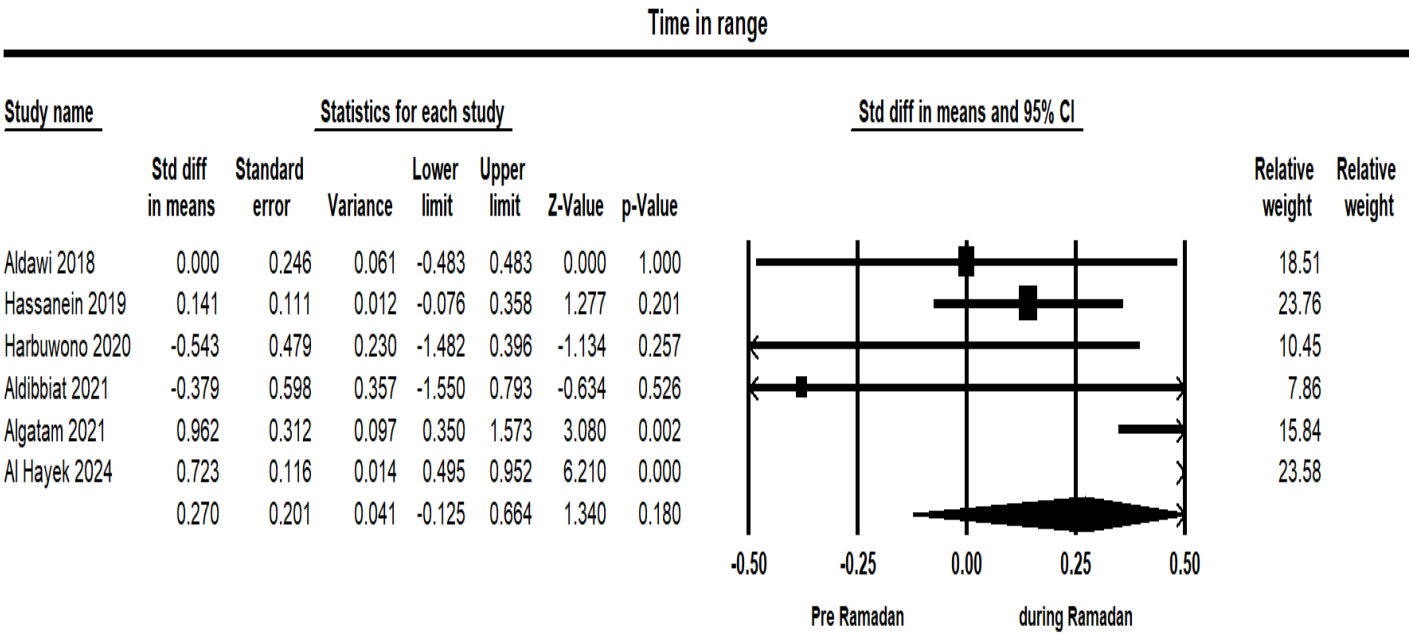
Time in range (TIR): TIR data were available from six of seven studies (**Table 3; Figures 3** and **4**). Results were heterogeneous across studies. AlGhatam et al. [15] demonstrated the most robust improvement in TIR during Ramadan compared to the pre-Ramadan baseline (63.0 ± 10.7% vs. 76.2 ± 16.2%; $p = 0.002$), representing the only significant TIR improvement. Hassanein et al. [12] and Al Hayek A, Al Dawish [16] also showed numerical improvements in TIR during Ramadan. Conversely, Harbuwono et al. [13] and Aldibbiat et al. [14] showed reductions in TIR during fasting. Aldawi et al. [11] demonstrated stable TIR across all phases. A post-Ramadan decline in TIR was observed in the study of Aldibbiat et al. [14] and Al Hayek & Al Dawish [16], highlighting the importance of sustained monitoring beyond the fasting period.

Table 3: Primary outcomes reported by each included study

ID	Ref.	Primary outcomes reported
S1	10	Mean interstitial glucose (IG), Max/Min IG, AUC, MAGE, HBGI, LBGI, % time in hyperglycemia, % time in hypoglycemia, hypoglycemia rate
S2	11	Interstitial glucose (IG), MAGE, CV, TIR, Time above range (TAR), Time below range (TBR), HbA1c
S3	12	HbA1c, hypoglycemic events, DKA episodes, hospitalization rates, TIR, TBR, TAR
S4	13	MAGE, average IG, Max/Min IG, hypoglycemia/hyperglycemia incidence, nutritional intake, physical activity
S5	14	Average glucose (used as surrogate for HbA1c), CoV, TBR, TAR, hypoglycemic episodes, insulin dose, insulin: carbohydrate ratio (ICR)
S6	15	Mean glucose, % time in hypoglycemia, % time in hyperglycemia, TIR
S7	16	Hypoglycemia and hyperglycemia frequency, mean glucose, GMI, TBR, TIR, TAR, glycemic variability (GV), low glucose events

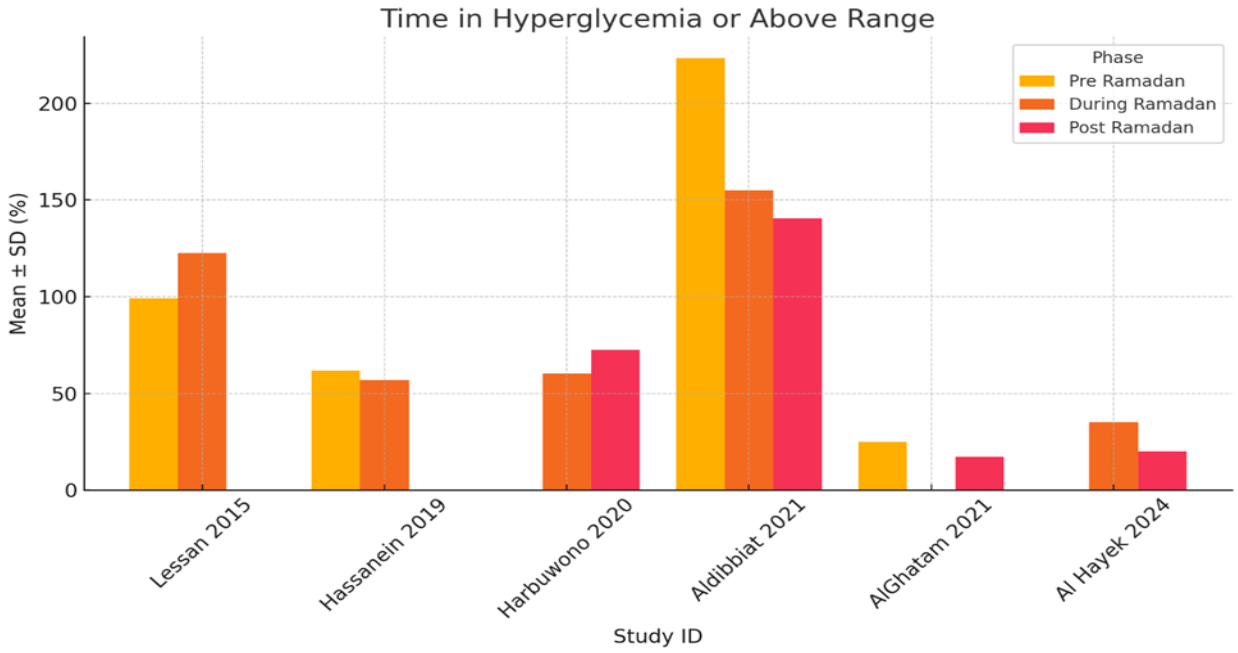
Figure 3: Time in range across Ramadan phases

Figure 4: Time in range



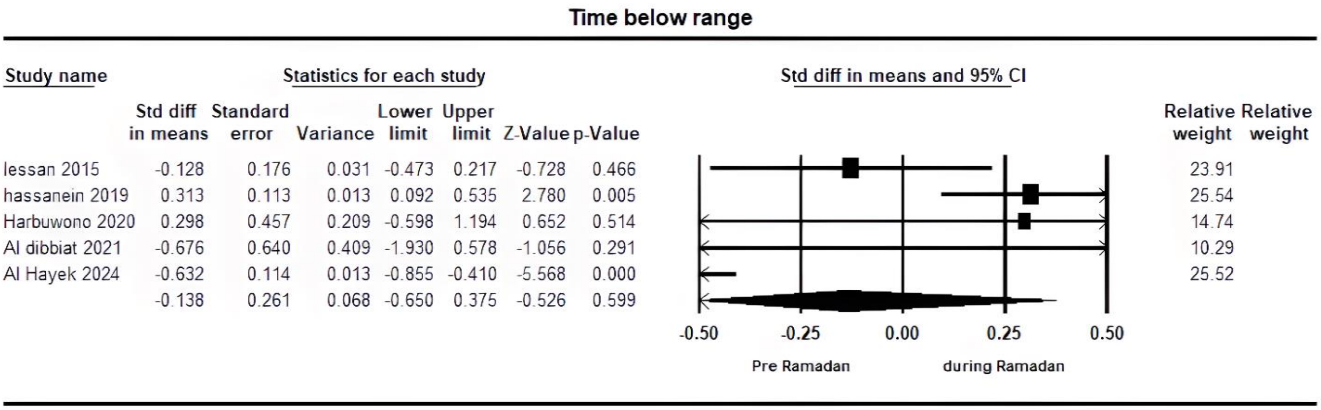
Time above range (TAR) - hyperglycemia: TAR data from six studies showed mixed directional effects (**Table 4**; **Figure 5**). Previous studies [12, 14-16] demonstrated reductions in TAR during Ramadan, suggesting improved hyperglycemia management with CGM-guided care. In contrast, Lessan et al. [10] and Harbuwono et al. [13] documented increases in TAR during fasting. A pooled meta-analysis for TAR yielded a non-significant result, reflecting substantial heterogeneity consistent with diverse study populations, diabetes types, CGM modalities, and concurrent treatment regimens.

Figure 5: Time above range across Ramadan phases



Time below range (TBR) - hypoglycemia: TBR data were available from six studies (**Table 4, Figure 6**). The pooled standardized mean difference for TBR during Ramadan compared to pre-Ramadan was - 0.138 (95% CI: - 0.650 to 0.375; p = 0.599), indicating a non-significant trend toward reduction in hypoglycemia time during Ramadan with CGM use. Individual study findings were inconsistent: Harbuwono et al. [13] and AlGhatam et al. [15] showed reductions in TBR during Ramadan, while Hassanein et al. [12] and Al Hayek & Al Dawish [16] showed increases. A notable post-Ramadan rebound increase in TBR was observed in Aldibbiat et al. [14] and Al Hayek & Al Dawish [16], warranting attention in clinical management planning.

Figure 6: Time below range across Ramadan phases



Mean amplitude of glycemic excursions (MAGE): MAGE data were available from three studies (Table 4, Figure 7). Lessan et al. [10] documented an increase in MAGE during Ramadan (104.5 ± 45.0 to 120.7 ± 61.3 mg/dL), suggesting greater glycemic variability during fasting for patients with Type 2 DM on oral therapy. Aldawi et al. [11] also showed a progressive increase in MAGE post-Ramadan. Al Hayek & Al Dawish [16] demonstrated a reduction in MAGE during Ramadan (38.2 ± 9.4 to 30.1 ± 12.8 mg/dL) with return to near-baseline post-Ramadan. The limited number of studies precluded formal meta-analysis of MAGE.

Table 4: Glycemic parameters across Ramadan phases- combined outcomes (Mean ± SD)

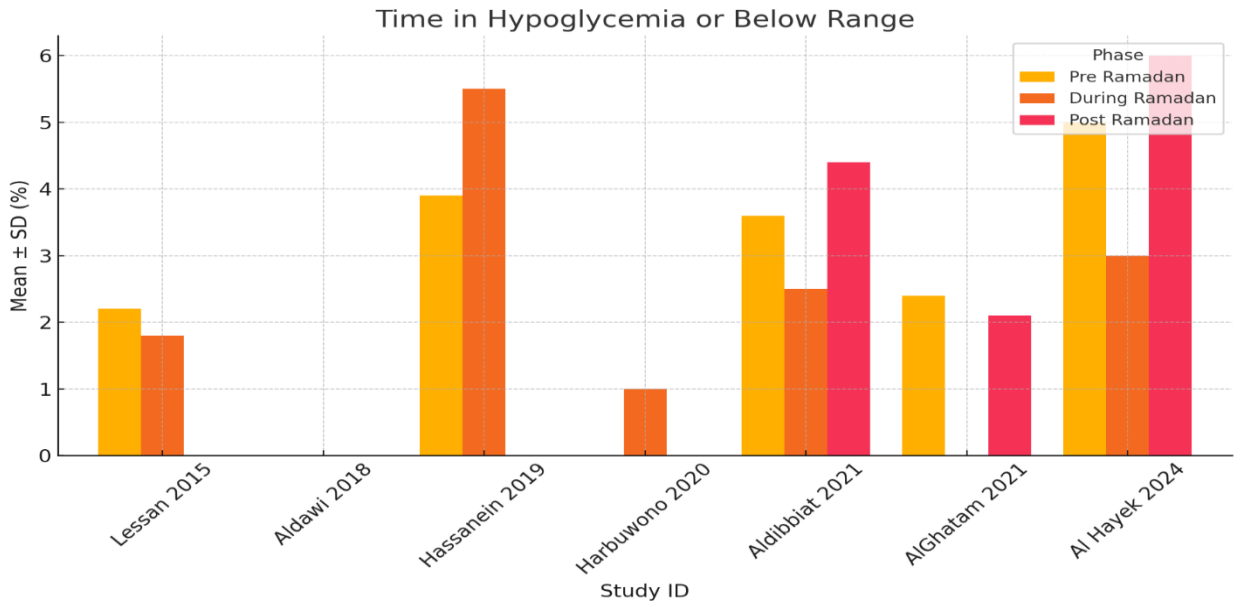
Parameter	Ref.	Pre-Ramadan	During Ramadan	Post-Ramadan
Time in range				
TIR (%)	11	92.0 ± 45.2	92.0 ± 63.0	91.0 ± 68.2
	12	34.7 ± 23.6	38.1 ± 24.5	-
	13	37.6 ± 9.6	26.9 ± 26.2	-
	14	41.4 ± 72.1	19.8 ± 36.0	18.0 ± 23.4
	15	63.0 ± 10.7	76.2 ± 16.2	-
	16	59.0 ± 31.0	76.0 ± 12.0	56.0 ± 24.5
Time above range - hyperglycemia				
TAR (min or %)	10	99.1 ± 97.3	122.5 ± 115.3	-
	12	61.8 ± 24.6	56.9 ± 27.3	-
	13	60.4 ± 30.9	72.4 ± 25.9	-
	14	223.4 ± 243.2	154.9 ± 124.3	140.5 ± 160.3
	15	25.0 ± 6.0	17.1 ± 10.4	-
	16	35.0 ± 20.0	20.0 ± 13.8	34.0 ± 15.0
Mean amplitude of glycemic excursions				
MAGE (mg/dL)	10	104.5 ± 45.0	120.7 ± 61.3	-
	11	73.0 ± 23.5	77.0 ± 23.5	89.5 ± 27.3
	16	38.2 ± 9.4	30.1 ± 12.8	38.0 ± 6.2
Time below range - hypoglycemia				
TBR (min or %)	10	2.2 ± 3.7	1.8 ± 2.4	-
	12	3.9 ± 4.9	5.5 ± 5.3	-
	13	1.0 ± 4.5	0.0 ± 1.5	-
	14	3.6 ± 1.9	2.5 ± 1.3	4.4 ± 2.5
	15	2.4 ± 1.7	2.1 ± 1.2	-
	16	5.0 ± 4.0	3.0 ± 2.0	6.0 ± 3.0

TAR units vary across studies (% of time vs. minutes); values are presented as reported in source publications. '-' indicates data not reported for that phase. TIR = Time in Range (70 - 180 mg/dL); TAR = Time Above Range (> 180 mg/dL); TBR = Time Below Range (< 70 mg/dL); MAGE = Mean Amplitude of Glycemic Excursions

HbA1c: HbA1c data were reported by five studies; however, pooled meta-analysis was not performed due to critical unit reporting inconsistencies identified across studies. Several studies appeared to report values in mmol/mol (IFCC units) without explicit labeling, while others used % (NGSP/DCCT). For example, values reported by Aldawi and others [11] (pre-Ramadan: 92 ± 45.2) are implausible in % units (which range 4.0% - 14.0%) but consistent with mmol/mol (≈10.6%). Similarly, values from Hassanein et al. [12] (34.7%), Harbuwono et al. [13] (37.6%), and Aldibbiat et al. [14] (41.4%) appear to represent mmol/mol values (approximately 5.3%, 5.6%, and 6.0%, respectively). In contrast, AlGhatam et al. [15] and Al Hayek & Dawish [16] appear to use % units (63.0% and 59.0% are implausible as % but consistent with mmol/mol near 79 and 75, respectively).

Narrative synthesis suggests a trend toward stable or minimally changed HbA1c during Ramadan across most studies, with the overall direction of effect being uncertain due to these reporting concerns.

Figure 7: Mean amplitude of glycemic excursions (MAGE) across Ramadan phases



Safety outcomes: Safety data were heterogeneously reported across studies. Hospitalization events were reported in Hassanein et al. [12], with CGM-guided education associated with reduced emergency admissions. No severe hypoglycemic episodes requiring third-party assistance were documented in the AlGhatam et al. [15] randomized study. DKA events were not reported in any study during the CGM monitoring period. Aldibbiat et al. [14] and Al Hayek & Al Dawish 16 documented post-Ramadan hypoglycemia rebounds, suggesting that risk does not uniformly resolve with Ramadan's end. Overall, the available data support a trend toward improved glycemic safety with CGM use during Ramadan, although the evidence base is limited.

Discussion

This systematic review and meta-analysis represents the first quantitative synthesis of CGM's impact on glycemic outcomes in patients with diabetes mellitus during Ramadan fasting. Synthesizing data from seven studies encompassing 485 participants across diverse geographic and clinical contexts, the review demonstrates that CGM use is associated with improvements in glycemic control - particularly TIR - and supports enhanced safety monitoring during this metabolically challenging fasting period. The most consistent finding was a trend toward improved TIR with CGM use during Ramadan. The significant improvement observed in the AlGhatam et al. [15] randomized pilot study (TIR 63.0% pre-Ramadan vs. 76.2% during Ramadan; $p = 0.002$) is clinically meaningful, as each 10.0% increase in TIR has been associated with reductions in HbA1c of approximately 0.8% and meaningful improvements in patient-reported outcomes. The failure of other studies to achieve statistical significance likely reflects their smaller sample sizes and methodological heterogeneity rather than a true absence of effect.

The mixed TAR findings - with reductions observed in insulin-treated patients using advanced CGM [14-16] but increases in patients using oral agents or older blinded CGM systems [10, 13] - suggest that the benefit of CGM is intimately linked to the ability to act on real-time glucose data. This aligns with the broader CGM literature demonstrating that the clinical impact of glucose monitoring is conditional on therapeutic responsiveness. The non-significant pooled TBR result (SMD: - 0.138; $p = 0.599$) should not be interpreted as evidence that CGM

fails to reduce hypoglycemia during Ramadan. The observed heterogeneity across included studies reflects genuine differences in diabetes type, fasting duration, baseline hypoglycemia risk, and treatment intensity. Furthermore, the post-Ramadan TBR rebound documented in Aldibbiat et al. [14] and Al Hayek & Al Dawish [16] highlights the importance of continued CGM-guided monitoring in the immediate post-Ramadan period, a clinical insight that would not be apparent without continuous monitoring.

The HbA1c unit inconsistency across studies - where values consistent with mmol/mol were reported without clear labeling - represents a methodological concern that extends beyond this review. It underscores the need for journals and authors to adhere to IFCC/NGSP dual-reporting standards (% and mmol/mol) in all future diabetes research publications. Future systematic reviews in this area will benefit substantially from this standardization. Contextualized within existing guidelines, these findings align with and extend IDF-DAR recommendations emphasizing individualized, technology-assisted monitoring during Ramadan. CGM provides the real-time data substrate required to implement personalized insulin dose adjustments, dietary modifications, and timely Iftar/Suhoor decision-making - capabilities that self-monitoring of blood glucose (SMBG) cannot match during prolonged fasting windows.

Some limitations of this review must be acknowledged. First, the small number of included studies and their modest aggregate sample size constrain the statistical power of pooled analyses and the robustness of conclusions. Second, substantial methodological heterogeneity - in CGM technologies, diabetes types, treatment regimens, Ramadan fasting practices, and outcome definitions - limits direct comparability across studies. Third, the absence of a control group (SMBG-only) in most included studies prevents attribution of observed changes solely to CGM use versus other concurrent interventions such as Ramadan-focused diabetes education. Fourth, the review protocol was not prospectively registered in PROSPERO. Fifth, publication bias cannot be excluded, as negative or null results may be less likely to be published. Finally, generalizability is limited by the geographic concentration of studies in Gulf Cooperation Council countries, with limited representation from South and Southeast Asia - regions with large Muslim diabetic populations. Future research should prioritize large-scale, multicenter RCTs employing standardized CGM protocols, uniform outcome definitions, and consistent HbA1c unit reporting to generate higher-certainty evidence in this field. Future large-scale, multicenter, standardized trials are needed. This review represents the first quantitative synthesis of CGM efficacy during Ramadan, providing an evidence foundation for clinical guideline development.

Conclusion: This study demonstrates that CGM technology is associated with improved time in range and a trend toward enhanced glycemic safety during Ramadan fasting in individuals with DM I and DM II. While pooled meta-analytic results for TBR and TAR did not achieve significance, likely due to heterogeneity and limited sample size. This study provides the first quantitative evidence base for the integration of CGM into Ramadan-specific clinical guidelines.

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Key message

CGM significantly improves Time in Range (TIR) for individuals with Type 1 and Type 2 diabetes during Ramadan fasting, with real-time data enabling timely glucose management decisions. CGM use is associated with a trend toward reduced frequency and duration of hypoglycemic events during fasting, enhancing patient safety. HbA1c outcomes show variability across studies; inconsistencies in reporting units (% vs. mmol/mol) in source publications complicate pooled interpretation and should be standardized in future research. Standardized CGM protocols are urgently needed to integrate technology-assisted monitoring into clinical guidelines for Ramadan diabetes management. This systematic review provides the first quantitative synthesis of CGM efficacy specifically during Ramadan, establishing a foundational evidence base for over 150 million Muslims with diabetes worldwide.